E-Health Services Role in a Smart City - A View after a Natural Hazard

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***Abstract*—Nowadays, Smart Cities are attracting much interest of researchers and also in the industry. One of the main reasons is the fact that this paradigm offers vast possibilities for been applied in many sectors like transportation, public service, healthcare, and others. Currently, almost all attention in the academic and business are put into the development of new applications or resources for taking advantage of this paradigm. However, what happens when an unexpected event makes that the smart cities applications work in the wrong way?. This paper states an approach for analyzing the smart cities considering an unforeseen event occurs like an earthquake. For achieving this goal, concrete and consistent exploration of the concepts and techniques involves in smart cities is conducted. As a result of that, several rules that must be followed to overcome these situations are analyzed, allowing to establish a characterization of the services that need to be prioritized inside a Smart Cities. Furthermore, we present some insights on possible solutions for the first prioritized services as e-Health or immediate communication necessity in affected zones to minimize the loss of living beings and maximize the rescue labors.**

***Index Terms*—Earthquake; Emergency Situations; E-health Service; IoT; Smart City.**

I. Introduction

INTERNET of Thing (IoT) is a paradigm of communication which has as the primary goal to establish an ideal framework to connect devices to the Internet [1]. It has opened a market that is currently gaining ground among sellers, manufacturers, and companies because of the opportunities it offers. According to the IDC forecast[1], the worldwide IoT market will reach the US $1.7 trillion in 2020 up from the US $655.8 billion in 2014 with a compound annual growth rate of 16.9%; this percentage is high due to the platforms, applications, and services offered by IoT. Furthermore, A Smart City coupled with the paradigm IoT take a complex ecosystem which involves a set of Information and Communication Technology (ICT) to deploy applications that solve problems of society, enabling improved environment, both economically, socially and environmentally, as well as in the quality of life of living beings [2]. The market includes the development of applications focused on service providers, citizens, government, communities, education, environment, transport, economy, agriculture, and others. In general, these applications are into personal, home, utilities, mobile, and business topics, e.g., those that include remote monitoring in health care through body area networks (BAN). Which help physicians to control patients without the need for check-up face applications [3], or intelligent transportation applications that help improve the timing and routes that citizens take to mobilize in a city [4], these applications play a role in the evolution of the city allowing a complex infrastructure of high level, as shown in Fig. 1.

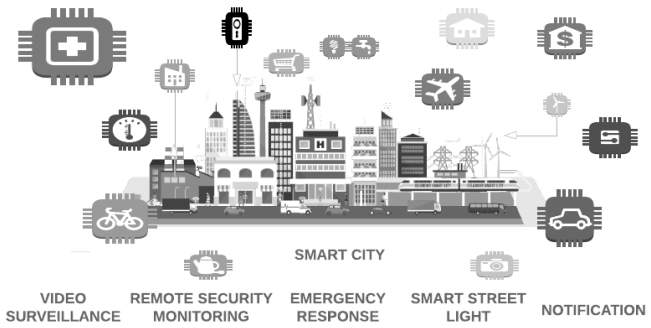

Fig. 1. Smart Technologies derived from the IoT paradigm for e-health.

On the other hand, whether we consider the entire amount of data flowing in the network; there may be collapsing in the communication networks, which is why we must use Big Data techniques that allow us to perform predictions and inference data [5], offering artificial intelligence through the methods of Machine and Deep Learning [6]. Despite technologies implemented to strengthen specific applications, most of them can affect the economic, social, and environmental development and cause monetary losses for a company or even natural disasters [7]. In this regards, e-health or m-health systems have vital importance due to their effectiveness in medical services. E-health services have been a breakthrough in the field of health, especially tele-medicine [8], e.g., allowing patients to prevent a possible attack by controlling their heartbeat. The advances in technology have contributed to this field, but What would happen with a city where this type of service exists, and an emergency like an earthquake occurs? [9], E-Health should prepare to serve anyone who needs help, but generally, patients in these situations take to health homes without knowing their medical history, much less if they have health insurance, which could cause chaos in these situations, leading to the patient worsening or dying in hospital facilities, e.g., Emily Ying Yang Chan et al. [10] describes a project in rural and remote ethnic communities facing public health risks related to disasters, evaluating the region's efforts in reducing health risk in emergencies. This project developed in Hongyan;

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[1]https://www.telecompaper.com/news/global-iot-market-to-reach-usd-17-tln-in-2020-idc–1085269

located in Sichuan Province of China, a survey was applied where 64% of the village had never considered disaster preparedness and taking e-health service to perform constant monitoring in these areas. In general, the problems that communities face could be improved, especially concerning natural disaster prevention. However, in the less expected moment an unforeseen event can happen that endangers any living being; from the smallest insect to the most significant animal, including humans with all the technology could be affected by these events, but, even though these are unexpected events, each living being continues with its lifestyle fulfilling its function in nature. Nonetheless, when we think that in the environment, there are beings more vulnerable than others. What will happen to these living beings after a catastrophic event, such as an earthquake or tsunami occurs? Are the government agencies prepared to face such situations? Alternatively, thinking about the most important, Can the Technology implemented in a Smart City help to rescue or save lives?.

This paper is divided into five sections. Section II describes emergencies that can harm a Smart City from damage to living beings. Section III presents the IoT taxonomy based on Smart City, from the communication protocols, data networks, standards and requirements that are necessary for the implementation of IoT applications and it describes the e-health services architecture and the role of Big Data in interacting with these computer systems. Section IV shows the different stages, from the implementation of IoT applications to the resources necessary for an e-health service to operate generally in an emergency within a Smart City. Finally, Section V presents the conclusions of this study to avoid significant losses in catastrophes.

II. Natural Hazard

Natural phenomena such as earthquakes, floods, landslides, mud-flow, avalanches, hurricanes, cyclones, tornadoes, tsunamis, volcanic eruptions, droughts, fires, erosion, and deposition of soils, among others, are the natural phenomena which could cause damage to the countries of The Pacific Ring of Fire [11]. According to Maskrey *"A natural disaster is a coincidence between a dangerous natural phenomenon and certain vulnerable conditions"* [12], e.g., On April 16, 2016, in Ecuador[2], an earthquake with 7.8 magnitudes on the Richter Scale in the coastal zone happened, where communes from Esmeraldas and Manabí provinces were the most affected with 670 of human losses, and uncountable economic loss in physical infrastructure. On September 2017, Hurricane Irma ripped through several islands in the Caribbean. The storm destroyed buildings and left hundreds of thousands without power[3]. These natural disasters go in those countries severe damages and losses both in human lives as physical infrastructure [13]. Some emergencies do not immediately harm the life or health of the person, but affect the nature and therefore, the creatures that reside in it. Although some government agencies do not consider it as a real problem, if we think as an example a forest fire affecting several hectares, it harms all animals and more whether this is a nature reserve. Also, if different variables are considered, such as wind speed and the ambient temperature, the fire can reach residential areas damaging physical structures, including human lives.

Besides, in daily living, emergencies can cause danger to the life of a single person, such as some medical emergencies including heart attacks, psychological trauma, strokes, cardiac arrest, and so forth. Even natural disasters, after they occur, bring with them different diseases, such as cholera and malaria, which threaten the lives of survivors [14]. Currently, the IoT paradigm is helping to solve various of these issues in different areas in order to establish Smart Cities, which can improve the quality of life of human beings and the environment that surrounds them [15]. In this study, we will focus on the devastation that can cause natural hazards in a city, specifically in the loss of communication, lack of supplies, and loss of human lives.

[2]https://cnnespanol.cnn.com/2017/04/13/a-un-ano-de-la-tragedia-que-sacudio-a-ecuador-que-ha-pasado-desde-el-terremoto/

[3]https://money.cnn.com/video/news/2017/09/14/irma-destruction-caribbean-orig.cnnmoney/index.html

III. E-health in Smart Cities

E-health Service applied to a Smart City is secured to the taxonomy of IoT, enabling developing applications to serve humanity. The taxonomy allows having a Smart city by specifying communication protocols, types of networks, services that can offer, and the crucial requirements for their implementations. An overview is shown in Fig. 2.

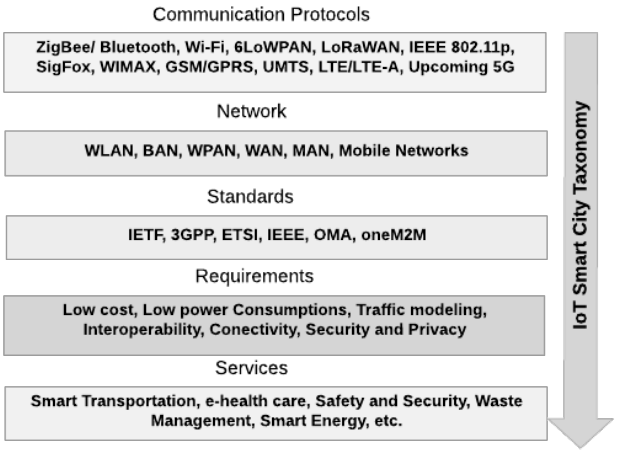

Fig. 2. A representation of IoT Smart City Taxonomy.

A. IoT Smart City Taxonomy

In communications, several short- and wide-range communication protocols are presented for the transfer of data between devices and servers [1]. Among the most used short range: ZigBee, Bluetooth, Wi-Fi, WiMAX y IEEE 802.11p, which can be used in indoor and outdoor sensor networks, Intelligent Transportation System (ITS), near-area monitoring, e-health, safety, near-field telemetry, and others. Moreover, If wide-range protocols such as Global System for Mobile Communication (GSM), General Packet Radio Service (GPRS), Long Term Evolution (LTE), Cellular IoT (C-IoT), Third Generation Partnership Project (3GPP) are also used, it will allow applications to cover areas of communication in global environments by generating what is known as a Smart City. Besides, the Lora Alliance is standardizing

the LoRaWAN protocol [16] to support smart city applications, primarily ensuring interoperability between several operators. Moreover, SIGFOX [17] is an ultra narrowband radio technology with full star-based infrastructure that offers a highly scalable global network and the Future Generation Communication 5G[4] [18], [1], [19].

In IoT, the communication of objects with the Internet facilitates the deployment of applications within a Smart City, e.g.: a Local Area Network (LAN) can contain logistics systems, meteorological, sensors, among others, that when trying to communicate with the cloud or external servers are obliged to use a Wide Area Network (WAN) to establish a communication link proceeding to make the calculations computations necessary for the correct operation of the applications. Similarly, in the mobile world; a network (indistinct from service providers and communication protocol) can be used to apply the concept of Smart City due to mobility and real-time interaction with the human being. Besides, smart city applications not only demand the deployment of different types of IoT devices but also require device interoperability. Therefore, most of the standardization organism such as the Internet Engineering Task Force (IETF: https://www.ietf.org/), European Telecommunications Standards Institute (ETSI: http://www.etsi.org), The global standards initiative for Machine to Machine Communications and the Internet of Things (oneM2M: http://www.onem2m.org), The Institute of Electrical and Electronics Engineers (IEEE: https://www.ieee.org/), Third Generation Partnership Project (3GPP: http://www.3gpp.org), and Open Mobile Alliance (OMA: http://openmobilealliance.org) are actively involved in developing standards to support smart city applications on a large scale [1].

IoT allows the deployment of countless applications in a Smart City, but for its proper operation several essential aspects must be considered, such as the low cost of the equipment (sensors, servers, cabling), energy consumption must be the minimum, thinking that within the city, there will be several devices sending information to a central or distributed server; in order to avoid excessive charges in the city's electricity consumption as well as in the useful life of the equipment. It is possible by designing a process which recollects data from time to time or monitoring the traffic of the data to the servers (data traffic modeling), interoperability between different communication technology, easy access between data networks, connectivity without interruptions, low latency especially in applications of Smart Health Care, Security and Privacy; this last one is the main one that the administrators must have very pending, since being applications of IoT (objects connected to the Internet) can be easily hackable generating problems to the systems. A useful communication model in an environment of sensor networks (communication with Zigbee, RFID [20], Bluetooth, Mobiles) that can be easily adaptable to IoT applications. Furthermore, an ad-hoc network with homogeneous Gateway [21] can be used where it will be responsible for sending the data to the servers can even be processed to set thresholds of when to send [22], avoiding an undue consumption of data, latency, and bottleneck.

[4]https://www.globallogic.com/wp-content/uploads/2015/12/The-role-of-telecommunications-in-smart-cities.pdf

B. E-health Service Architecture

The IoT Smart City taxonomy incorporates a set of communications protocols, data networks, standards, and requirements for the creation of applications in a city. However, special care must be taken to implement e-Health Care Services, not only because it is a category dedicated to health and medicine, but rather because it deals with issues that can be detrimental to a person's life. Also, topics related to security and privacy should be evaluated before marketing e-Health applications. An excellent example of this type of service is m-Health applications that have flooded the market due to the Smart-phones and wearables that facilitate the sampling and measurements of the users due to the large number of sensors that these devices include [23]. M-Health applications are based on a set of Internet and computing technologies, communication and information systems, and sensors and wearables devices connected in a body area network (BAN) [24], personal area network (PAN), etc. [25], which are used to obtain real-time data which is sent to the computer center to be analyzed by doctors and take control of their patients. Even if we talk about the future of IoT in this field, these include developing new enabling platforms for an aging population, such as detecting the activities of daily living [26], monitoring social interactions and chronic disease management.

In this regard, e-health introduces a new health care connectivity paradigm that interconnects IP based communication technologies such as near field communications (NFC), 6LOWPAN, Low power Bluetooth and emerging 5G networks for future Internet-based health care services. Thus, the develop of m-IoT applications is required due to the high demand for care in homes; where both patients and their caregiver will be benefited, from the personal and monetary point of view. So, constant transfers for routine checkups medical can be avoided; mobility cost in health care can decrease, flow, and improvements in clinical outcomes can be optimized. Likewise, a broad growth in the infrastructure of data networks and medical devices using wireless communication to read data and transmit through different systems until they reach the specialist doctor.

E-health applications should be designed so that they do not interfere with patients' daily lives [27]; leaving them to express themselves in a secure environment, peace of mind, food and drink contacts with friends and family, including giving reassurance physical, social and mental stimulation. When we talk about e-health, most applications follow the same pattern [28], which is described in Fig. 3.

Sensor Data Collecting Layer - Data acquisition is performed through multiple sensors responsible for measuring physiological signals, such as body temperature, heart rate, respiratory rate, heart rate, muscle activity, and others. The sensors are connected to a gateway, which is responsible for processing the data before being delivered to the doctor; generally, it is a mobile (cellular) base located in the vicinity of the patient [28]. Sensors built into the BAN should be lightweight, small and should not hinder the individual's movement, even if they use rechargeable or replaceable battery [29], they should ensure that the data is not lost during replacement periods. Besides, the current sensor designs are flexible because they can be placed anywhere on the body generating more robust medical applications, and due to the

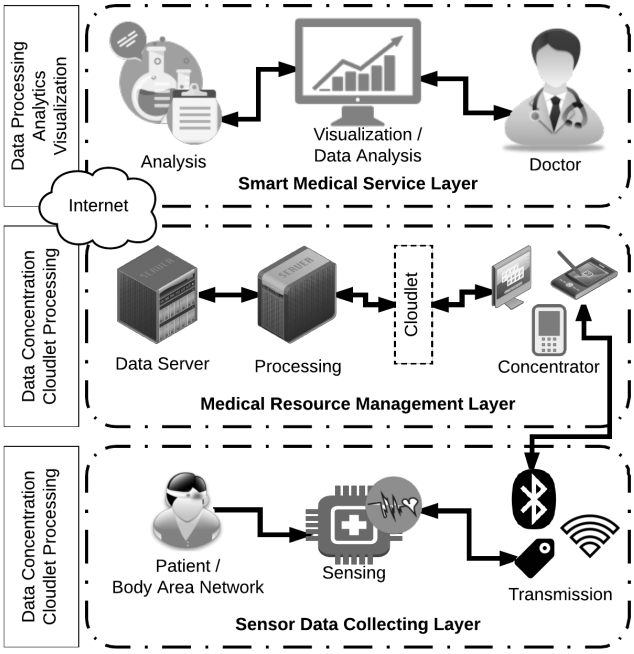

Fig. 3. Outline of an E-health Architecture.

proximity and the contact with the skin the sensors allow measuring specific physiological parameters. In this context, a detection architecture based on IoT facilitates the implementation of these schemes, since they adaptively improve energy efficiency, allowing the use of sensors based on the patient needs. Due to the energy limitation of these devices, these may require low power communication protocols such as ZigBee (IEEE 802.15.4) or Bluetooth (IEEE 802.15.1) that are used in low-speed WPANs [30].

Medical Resource Management Layer - Storing data in the cloud offer scalability and accessibility benefits of demand from both patients and clinical institutions. Also, hosting and processing can reduce costs by providing better diagnostic information. Although there are issues that need to be considered in medical data stored in the cloud such as [28]:

- *Hybrid Cloud/Cloudlet Architecture*: Cloudlets have been introduced as a solution to deliver low latency to monitoring tasks through PANs. Besides, the communication between the concentrator (mobile) and the Cloudlet is done through a Wi-Fi interface, reducing latency and data transfer [31], [32], although the use of LTE is not highly recommended because it is exposed the transmission of data to the lag produced by the mobile network.
- *Privacy Patient's Data*: The patient information can easily be compromised, because a PAN or BAN is connected to a hub, and anyone with a simple sniffer could capture the network packets, revealing the patient's status and vulnerabilities. It is recommended to use encryption techniques to ensure data security. [33].
- *Secure data storage in the cloud*: Per the terms defined by the Health Insurance Portability and Accountability Act (HIPAA), medical records must be disclosure protected, taking appropriate actions for preventing unauthorized accessing to this information. Medical data processing in the cloud is still a challenge in IoT applications [34].

Smart Medical Service Layer - The sensors can incorporate multiple physiological samples to the traditional office and laboratory measurements, allowing to improve the patient's treatments. This dataset brings the possibility of performing data analysis, and define a machine learning model for disease prediction or detect improvements in the process of clinical diagnostics [35]. However, before being used on a large scale, some challenges must be overcome, these include the approval of the regulatory requirements for the Medical equipment, the training of medical staff, etc., which makes that these innovations won't be adopted speedily. Usually, analyzing the massive amount of data that the sensors provide is a very complex task. However, with the emergence of Big Data for the manipulation of large volumes of information, many algorithms and methods have been developed for the processing of medical data [36]. One of the most common problems presented in this field is that the data have not a semantic association. Thus, the learning process may not work; one possible solution to this problem is to take advantage of the clinical records that different entities have stored in their electronic systems.

Similarly, visualization of data in the medical field is essential, because bar charts, pie charts and other can be used to represent the development of a disease, and therefore doctors find it easier to indicate the conditions of a patient. Due to the high volume of data collected by the IoT sensors is necessary to include modern visualization tools for representing this information. Besides, a key aspect of portable detectors, regarding the data acquired in a laboratory, is that data are collected over a much longitudinal way, with an excellent temporal sampling and simultaneously through multiple modes.

C. Smart applications and his role in E-Health

The technology represent a potent tool, we can have access to sensors, motherboards, and more instruments which can be used by researchers, scientists, universities and even high school projects, to promote the creation of IoT applications. These components incorporated into a communications network, allowing have applications or objects connected to the Internet [37]. The following describes specific Smart City applications that contribute in some way to e-health services.

- **Smart Transport**: One of the most critical aspects to consider within a Smart City is mobility. It can improve the safety, efficiency [38], [39], [40], quality of life and time of journeys of users within of cities, e.g., Using sophisticated sensors, an autonomous vehicle can include a personal assistant, self-driving and self-parking capabilities, control the intensity of the lights [41] and even improve in the reduction of CO2 emissions. Indeed, whether the driver suffered any emergency, the car could go by itself to the nearest hospital. Finally, lanes dedicated to bicycles [42] can provide an alternative to the use of automobiles, reducing the emission of gases and improving the health of the users.
- **Smart Public Services:** The aim is to deploy public resources efficiently and effectively. Therefore, the applications should include adaptive management of the resources, e.g., by optimizing routes for waste collection

or the installation of smart trash cans that send alerts when full [37].

- **Smart Building:** The aim is to make residencies, homes and commercial buildings more sustainable, based on energy efficiency to improve the quality of life, e.g., smart buildings can monitor their structural health [43], regulate lighting and heating based on presence detection, and use intelligent appliances to automate everyday tasks [44].
- **Smart Environment:** The aim is to improve the quality of life and safety of citizens [21], e.g., Avoiding noise in cities [45], early warning of incidents or unforeseen events, congestion maps of people and safe areas in case of natural disasters, e.g., earthquakes [11], floods, volcanic eruptions, tornadoes, and forest fires.
- **Open Data:** It refers to data that is publicly available and may be used and analyzed by third parties (legal openness) [37], [46], [47], [48]. Cities can use open source platforms like JKAN to release data and to use the information to create a new application to help people.
- **Smart Citizens:** This concept is related to the creation of communities [49], e.g., smart education uses life-long learning programs, which may focus on employability, digital inclusion [50], or specific population groups, e.g., children with autism, elderly or those with physical disabilities.

The goal is to improve health-care systems, making them more effective and efficient in the care of patients being this manually or remotely [51], e.g., The wearable devices could send information from patients with a disease (cardiac pathologies, insufficiencies, arrhythmias, and so on.) to real-time monitoring systems, allowing doctors to act in the shortest possible time when something unforeseen is happening [52]. Ambulances could send real-time measurements of a patient to the emergency room so that when arriving the hospital, the doctor has all the results and administer the most effective medication for his/her speedy recovery, or even saving the patient's life. Indeed, ambulance drones could be incorporated for sending them to remote or painful areas in optimal times, avoiding jams and land routes [53].

D. Reliability and Data Accuracy

In Big Data, there are three distinct characteristics; volume, speed, and variety [54]; but, James et al. [55] introduced two essential attributes in the field of Big Data in health, which are the veracity and value of the data. Although, in other areas may be in the background, in health are considered very serious to treat a pathology with reliable data. Since the last decade, the data concerning health have increased due to the application of Smartphones and Digital Services [56]. Among the most common data, we have 3D images, medical records, radiology images, and biometric sensor reading. The amount of space occupied by these data is enormous compared to other applications. Although, the recent advances in technology management, data processing, and machine learning are allowing to develop effective platforms for handling this type of issues.

In smart e-health systems, data collection and modeling processes are carried out at high speed, which means that there is a growing healthcare data to give immediate feedback about the patient and his environment [5]. In healthcare applications such as clinical text mining, predictive modeling, survival analysis, patient similarity, genetic data analysis, and smart services, real-time processing is indispensable [57]. Although some data (like radiographs) are generally static, most of the health data are dynamic and regularly generated by multiple measurements such as glucose, blood pressure, and electrocardiogram (ECG). Extensive data can never be 100% accurate, and therefore, it must be constructed with high attention to be clinically useful. Due to this type of data are incredibly dynamic and susceptible to errors, data quality problems are a significant concern in healthcare [57]. Hence, for providing the first level of consistency between different hospital services, systems must filter out erroneous data based on thresholds determined for each patient. However, speed in obtaining data hinders the ability to clean the data before using and processing it by keeping its authenticity [58]. Therefore, it is essential to have a "truth value," allowing the data to be more efficient and precise when making a decision.

IV. E-HEALTH FACING A NATURAL HAZARD

Concerning Smart Cities, countless applications can be incorporated into the city, but what happens when there are unexpected events which have not been considered at the time of implementing a Smart City? Currently, smart cities have been deployed in several areas around the world, e.g., the Santander City (Spain) has the SmartSantander project that has implemented applications of surface parking, intelligent systems, augmented reality, information environments, light control, and others [59]. As a general point, it is possible to mention that municipalities around the world should apply the Smart City concept to improve their places, but, Is it feasible and viable in all the cities even when the terrain, climate and weather conditions of a specific area are not suitable for the implementation? On the other hand, whether the Smart City concept is applied in a city with the appropriate regulations, standards, and applications, it should be successful, but there are some adverse conditions that humans being cannot control like natural disasters. Even lack of communication on devices for a long time, unexpected application crashes, vulnerabilities in security and privacy, data alteration and others could cause severe damage to the city [28]. Although, these events can be resolved immediately (depending on the staff), the most severe concern is if the Smart Cities are prepared for facing emergencies generated by natural disasters. When an emergency arises in a Smart City, health services come to the forefront of others, due to the primary goal is to preserve the of living beings [60].

A. Disaster planning

Disaster planning allows authorities to act quickly and effectively when an emergency occurs. Also, it facilitates the rescue, relief, and rehabilitation with available local resources. If those are not enough, new resources are identified in the regional and national levels, and finally at the international level. Active preparations for disasters include [61]:

- The establishment of local emergency committees.

- Development and implementation of emergency operations plans.
- Staff training, including practical and simulation exercises.
- Acquisition of emergency equipment and supplies.

Moreover, Disaster plans are always evaluated through three phases: pre-disaster; when all systems work correctly, emergency event; in our case natural hazards, and post-disaster; the standards that must be carried out to face such situations.

B. Pre-Disaster: Prevention

An efficient organization should incorporate concepts of prevention in all its activities, including operations, maintenance, and administration [61]. If we consider this aspect, each application which comes as a society requirement needs to be planned, modeled, tested and improved depending on each case. Those processes constitute a cycle which can be repeated until its first publication on the market. Then, recommendation or improvement phase comes which are handled by experts, based on user feedback and which can be improved by using the IoT taxonomy for Smart Cities [62], to deploy the application in the city generating a Smart Service (Transport, Home, Health, Governance, Education, etc...); although generally the deployments are handled by service providers (ISP, Hosting) [63]. The critical point is to maintain a robust technology infrastructure for all applications because it is necessary to keep constant communication, real-time store data (Big Data) and perform due processing for human interaction with the system functions. Besides, combining Big Data and Machine Learning techniques in a structured and unstructured dataset, the user can be assisted with product or service recommendations, pattern inference, prediction, early warning, among others [5], with the only purpose of technology is to bring the Smart User. In Fig 4 is shown the model to implement an IoT application in a Smart City.

C. Emergency Event

Emergencies such as cyclones, earthquakes, tsunamis, disease outbreaks, radio-logical incidents, and chemical spills have important implications for public health. Also, the crisis within health facilities, such as fires, loss of electrical supplies, water, food, and medicine can damage buildings, equipment, and affect the staff and patients. In risky situations, a hospital may cease to function, among other things, because the team is forced to leave the hospital for safety reasons [64], or equipment and drugs are looted. These conflicts have caused a significant amount of human suffering around the globe and have made health services have to be used thoroughly [65], [66], [67]. However, if buildings were built to be able to withstand in a better way the impact of earthquakes, a significant number of human lives could be saved [68]; also, an effective early warning system and adequate preparation for cities and communities can save many lives [69], [70]. While 11% of people exposed to natural hazards live in developing countries, they represent over 53% of deaths from natural disasters. The differences in impact suggest there is an excellent potential for reducing the number of human deaths caused by natural disasters, being human inaction one of the elements which contributes to enhances this type of situations. It is often believed that the risk of disease outbreaks in the chaos that follows natural disasters is very high, and the fear likely derived from the association of corpses and epidemics. However, risk factors for catastrophic outbreaks are mainly linked to population displacement (usually associated with conflict). Even the presence of some cases of a particular disease can lead to the perception that the population is facing a severe health risk, which can lead to significant political, social and economic consequences [71].

Moreover, a quick assessment of the emergency is crucial for guiding relief operations. The observations must be recorded in previously prepared formats to have an accurate and uniform representation. This evaluation includes the damage description, the action required, the available capacity, and the human and material resources. Also, measure and express the damage in percentages or quantities is essential. On the other hand, accurate evaluations and requests for external assistance facilitate the immediate intervention of the relief staff and the delivery of adequate supplies. If the claims are not specific, the goods received may be inadequate for recovery and may even aggravate the emergency [61].

D. Post-Disaster: Rehabilitation

This phase involves recovering the most critical services (Health) after the disaster and also implement long-term measures for the reconstruction of the affected areas [61]. Usually, when a natural disaster occurs, the city is devastated, and the health services should reinforce their actions to avoid epidemics or other problems that can affect the survivors. If a Smart City is exposed to the same situation, the effects will be slightly less severe due to, with the implemented e-health services is possible to provide access to systems, resources, data storage (available medicines), even the users' medical history, e.g., suppose that an earthquake occurs in a Smart City, and it is possible to access the patient's medical history based on the routine checkups. In that case, if a member of a relief body encounters a person with a critical state of health and he doesn't know the clinical antecedents of the patient, is difficult to know which drugs could damage instead of healing the patient health. However, if the patient's medical history could be accessed by applications based on their identification (license, biometric fingerprints, DNA analysis, and others [72]), such applications could improve response intervention by relief agencies. Although, there are legal problems which could cause that vital information like medical history cannot be available during an emergency: public authorization permits from ministries of health, insurance company and problems between private and public clinics [73].

In our context a natural disaster like Earthquake (6.5 or higher on the Richter scale), which utterly disables a city; leaving it completely isolated, without communications and with breakdowns in essential services (gas, water, and electricity). Therefore, food shortages and lack of preparedness to survive in somewhat hostile environments can lead to a city being aggressive and lose sanity before these circumstances [74]. In those situations, the first action to take is establishing a communication link; one option is using the country's

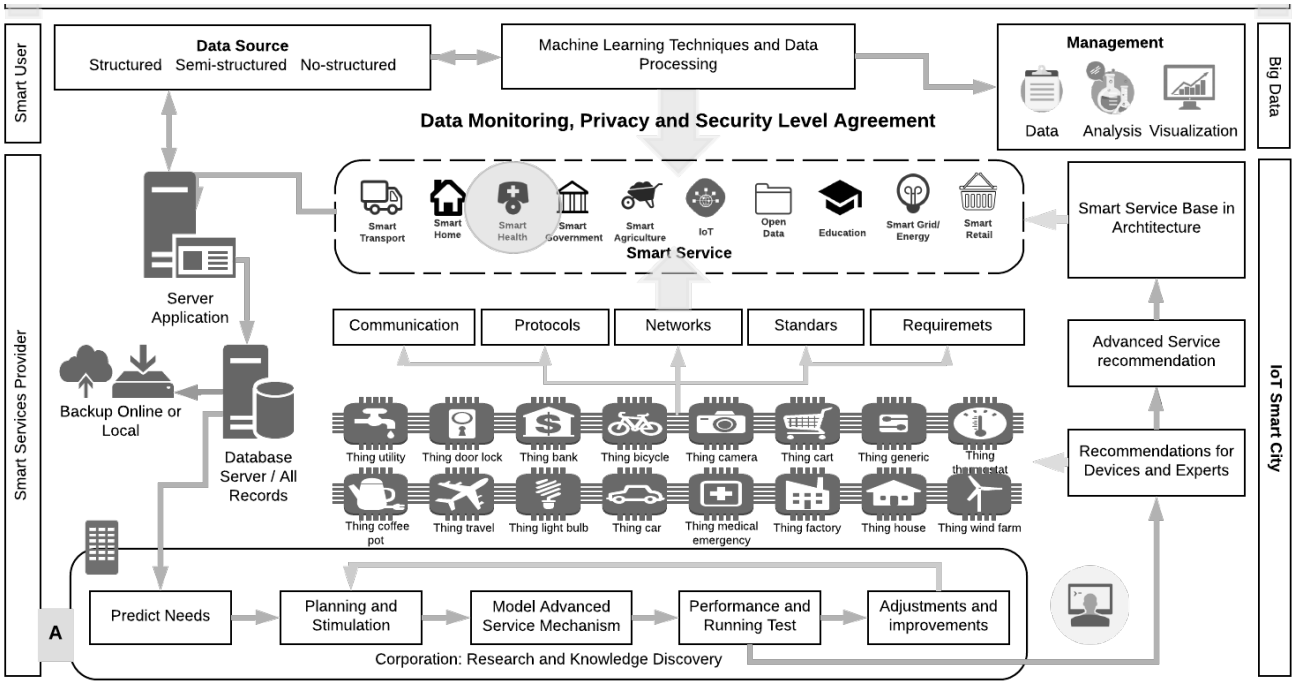

Fig. 4. Implementation of IoT Application in different fields of the city.

telecommunications operators through a mobile base for communicating with nearby cities and create a collaborative environment. Also, Radio links used by Radio Amateurs (RA) can be used as another way of communication. The RA's are duly authorized people who are interested in technical radio, for their personal and non-profit use [75], but in emergencies, they have all the appropriate equipment and resources to establish communication links to help the people which have been affected by those events. In general, the highest priority is to establish a route of communication with the outside as soon as possible. Once the channel is established, the next is to keep it fully operational (at least 24 hours), with operators listening to the emergency channels to act in consequence with the current situation in the shortest time possible. As shown in Fig. 5, where a communication channel shown to interact with applications or health services.

The communication channel serves as a route for accessing the e-health information, e.g., the medical history of each person. In these circumstances, it is crucial that all the public and private entities grant access to health records to the relief staff. The recognition of pathologies of patients, blood type, conditions, and allergies, become an aid for physicians and rescuers who are in the area, even if there are not specialists in the surroundings, doctors from other cities can guide on any procedure to those who are handling the case [76]. Also, applications such as facial recognition, pattern identification, user identification, can be beneficial thanks to Big Data techniques. Finally, and not the least important, there must be immediate communication with the relatives [77], for this the clinical database is helpful. In the context of emergencies, there will always be corpses that must be recognized immediately, not only to know the name of the person but to notify their relatives of the patient's status (Living, Critical or Dead) [78].

When a natural disaster occurs, electronic health services represent a strong point when evaluating these situations because they only focus on "public health." As indicated in previous sections, the main thing is to enable a communication channel, so that the requirements of the applications can be processed and thus be able to use the information found in different databases, medical records or fingerprints. Next, the possible e-health services/applications that would be useful in these situations for being implemented on a large scale, are listed:

- ***Libelium MySignals Application*** - Libelium is a company dedicated to developing end products in the field of IoT. In e-health, they have developed a biometric platform that allows creating new software applications with medical devices to measure 20 different body parameters, among them: heart rate, glucose, airflow, pulse, oxygen in the blood, blood pressure, and others [79]. All biometric data are encrypted and sent to the Libelium cloud platform in real time to be viewed for later analysis [80]. Although this information is only for personal use or the primary care physician, it is information that is available about the person and that in an emergency it would be useful to know the patient's medical history on behalf of the first responders.
- ***Telefónica E-health*** - Telefónica focus on the development of mobile e-health services; Due to the robustness of their communications, they offer certain e-health services in collaboration with different companies[5], such as: Axismed, the management of chronic patients in Brazil or Telefónica R&B, Rempark for the remote monitoring of motor symptoms and remote management of the treatment of this disease; and Mobilesage, to design the first mobile on-demand assistance service, conceived for the elderly, using proximity technologies

[5]https://www.telefonica.com/en/web/responsible-business/-/ehealth

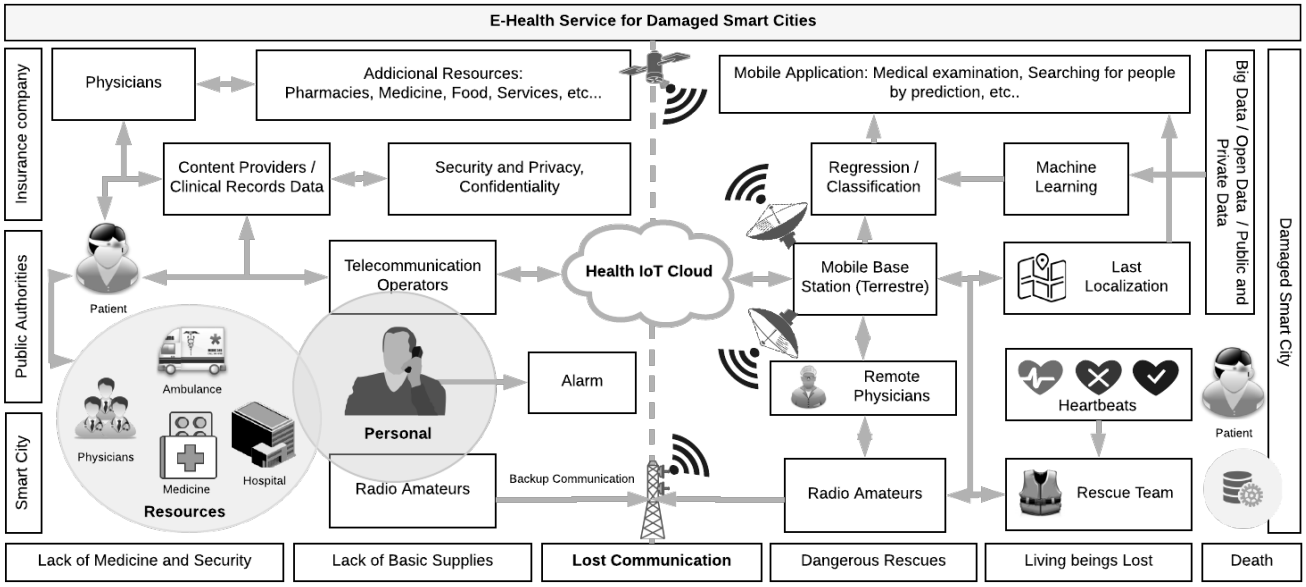

Fig. 5. E-health Service Architecture for a Damage Smart City.

such as NFC and QR codes. Also, a service of telehealth and telecare, this service enables to access their daily medical agenda (with times for the taking of tests, medicines, consultations, etc...) and send your medical parameters and symptoms in a precise, secure manner.

- ***Smart Wearable Devices*** - These are products on the go [81]. A patient can use them to assess their health status or fitness regime without any professional help [82] . These devices can help in checking blood and glucose level, body temperature, heartbeat, cardiovascular problems, vision quality, and chronic ailments. Also, They have been a boom for diabetic, asthma and heart patients. Products like fitness tracker or fitness bands have gained immense popularity amongst fitness enthusiasts. Companies like Fitbit[6], Under Armour[7], are showcasing new technologies in these products.

Finally, these applications can be used to improve rescue situations, but the different prevention mechanisms must always be taken into accounts, such as vulnerability assessment, planning, institutional framework, information systems, and the resource base, alert systems, the response mechanism, public education and training, and rehearsals to avoid severe damage to a Smart City and all the lives living there.

V. Conclusions and Future Works

Natural disasters occur unexpectedly and have the power for destroying whole cities, slowing down the social and economic development of communities and, also causing severe health problems that harm all living beings (animals, humans, flora, and fauna). Therefore, the importance of implementing e-health systems for emergencies is exceptionally high. Due to that these systems allow providing the necessary information to help both physicians, patients, and the environment around them.

The set of technologies applied to data, city, and health will allow people to learn from different problems by generating innovative visions in the real world, exploring aspects such as automated health management, proper use that provide a city and others. Moreover, the amount of data and technology that we have in these days make it challenging to guarantee security and privacy, maintain control and quality in the city and refine the computational tools for handling information. In this regards, some gaps must be broken, including: Improve the context-aware health paradigm. It is strengthening the supply chain management system in the healthcare context. To analyze the prospects of the healthcare industry with new data sensing intelligent systems and social media capabilities for exploring a common healthcare platform through sharing health data and collaborating with partner organizations and Conduct complementary research on information privacy and security issues.

Finally, if this technological tools that help a great extent to the development of a city, suffer some damage, alteration or are destroyed, what could we do to recover it?. Although the restoration can be carried out, precautions must be taken in regard this recovery takes the shortest time possible, always bearing in mind that the lives of human beings are at stake. For this reason, an open data policy is needed so that applications dedicated to health can be used immediately, and consequently, the relief agencies proceed in the fastest and efficient way.

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